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By:
Harry A. Angel, Paul G. Santos Vilhena, and Andrew Morton

Human*systems*® Incorporated
111 Farquhar Street, 2nd floor
Guelph, Ontario
N1H 3N4

Project Manager:
Harry A. Angel
519-836-5911

PWGSC Contract No. W7711-037871/001/TOR
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DRDC-Toronto Scientific Authority
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On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by
Defence Research and Development Canada - Toronto
1133 Sheppard Avenue West
North York, Ontario
M3M 3B9

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Abstract

A four-day field trial was undertaken at CFB Edmonton over the period of June 12 to 16 2006 to evaluate the difference between constant and variable thickness ballistic visors. Twenty infantry soldiers, regular (n=5) and reserve (n=15) force, of various Canadian units were required to undertake a battery of human factors tests while wearing two different visor conditions in a fully balanced repeated measures design. The trial was split into three phases: clinical testing, trial overview, and scale explanation; dynamic activities; and focus group. Evaluation exercises included an obstacle course, wooded lane course, vehicle course, urban vehicle patrol course, night patrol course, and FIBUA assault. The participants rated visual characteristics, visual acuity, and task acceptability of the visors for each evaluation exercise. Data collection included target detection performance measures, acceptability ratings, preference rankings, and focus group. Overall, a constant thickness ballistic visor was preferred by participants to a variable thickness ballistic visor for the majority of the human factors criteria. Objective target detection performance data showed no differences between the visors. Clothe the Soldier (CTS) Project is recommended to proceed with the requirement for a constant thickness ballistic visor for the integrated ocular and upper face protection.

Résumé

Un essai sur le terrain de quatre jours a été effectué à la BFC Edmonton du 12 au 16 juin 2006 afin d'établir la différence entre les visières balistiques d'épaisseur constante et les visières balistiques d'épaisseur variable. On avait besoin de vingt fantassins, soit cinq de la Force régulière et 15 de la Réserve, appartenant à diverses unités canadiennes qui devaient entreprendre une batterie d'essais usuels selon une formule parfaitement équilibrée de mesures répétées en portant deux genres de visières. L'essai était divisé en trois phases : l'essai clinique, l'aperçu de l'essai et l'explication de l'échelle; les activités dynamiques; le groupe de discussion. Les exercices d'évaluation comprenaient un parcours du combattant, un parcours en sentier boisé, un parcours en véhicule, un parcours de patrouille urbaine motorisée, un parcours de patrouille de nuit et le combat dans les zones bâties. Les participants ont coté, dans chaque exercice d'évaluation, les caractéristiques visuelles, l'acuité visuelle et l'acceptabilité des visières aux fins d'exécution des tâches. La collecte des données comprenait les mesures du rendement au niveau de la détection des cibles, les cotations de l'acceptabilité, le classement des préférences et le groupe de discussion. Dans l'ensemble, les participants ont préféré la visière balistique d'épaisseur constante à la visière balistique d'épaisseur variable concernant la majorité des critères. Les données objectives relatives au rendement au niveau de la détection des cibles ne montraient aucune différence entre les visières. On recommande, dans le cadre du projet *Habillez le soldat*, de continuer à demander une visière balistique d'épaisseur constante en vue d'assurer la protection intégrée des yeux et de la partie supérieure du visage.

Executive Summary

A four-day field trial was undertaken at CFB Edmonton over the period of June 12 to 16 2006 to evaluate the difference between constant and variable thickness ballistic visors. Twenty regular (n=5) and reserve (n=15) force infantry soldiers of various Canadian units were required to undertake a battery of human factors tests while wearing two different ballistic visor conditions in a fully balanced, repeated measures design. Seventeen male and three female soldiers were recruited for this experiment from various units. The mean length of service for the five regular force participants was 5.3 years in the regular forces (SD= 3.5, max= 10.5, min= 2). The mean service for the fifteen reserve force participants was 3.0 years in the reserve forces (SD= 1.8, max= 7.5, min= 1). Twenty-five percent of the participants wore corrective contact lenses during the trial. The trial was split into three phases: clinical testing, trial overview, and scale explanation; dynamic activities; and focus group. The participants rated visual characteristics, visual acuity, and task acceptability of the visors for each evaluation exercise.

A progressive four day testing protocol was used, from a static test stand in Phase 1, to dynamic discrete military activities tests in Phase 2 and finally a dynamic military battle task test in Phase 2B. Phase 1 consisted of visual acuity testing. Phase 2 included an obstacle course, wooded lane course, vehicle course, urban patrol course, and night patrol course. Phase 3 involved FIBUA fighting. Data collection included target detection performance, acceptability ratings after each task, and exit questionnaire acceptability ratings and preference rankings. Following the completion of all tasks for both visors, participants took part in a guided focus group.

Soldiers considered the constant thickness ballistic visor significantly more acceptable and ranked it better than the variable thickness ballistic visor. No significant differences between visors were seen in target detection performance or task questionnaire acceptability ratings for the night patrol task.

The results of this trial suggest that the use of a constant thickness ballistic visor is acceptable for ballistic protection of the upper face. In the present study, soldiers rated a constant thickness ballistic visor more acceptable overall than a variable thickness ballistic visor for the majority of the human factors performance criteria. The constant thickness ballistic visor was rated more acceptable and ranked better for obstacle course, wooded lane, vehicle course, vehicle urban patrol, night operations, and FIBUA tasks. Clothe-The-Soldier (CTS) should proceed with the requirement for a constant thickness ballistic visor for the integrated ocular and upper face protection.

Sommaire

Un essai sur le terrain de quatre jours a été effectué à la BFC Edmonton du 12 au 16 juin 2006 afin d'établir la différence entre les visières balistiques d'épaisseur constante et les visières balistiques d'épaisseur variable. On avait besoin de vingt fantassins, soit cinq de la Force régulière et 15 de la Réserve, appartenant à diverses unités canadiennes qui devaient entreprendre une batterie d'essais usuels selon une formule parfaitement équilibrée de mesures répétées en portant deux genres de visières. On a recruté dans diverses unités dix-sept hommes et trois femmes afin de mener cette expérience. Les cinq participants de la Force régulière comptaient en moyenne 5,3 années de service (écart type = 3,5, max = 10,5, min = 2). Les quinze participants de la Réserve comptaient en moyenne 3,0 années de service (écart type = 1,8, max = 7,5, min = 1). Vingt-cinq pour cent des participants portaient des lentilles de contact pendant l'essai. L'essai était divisé en trois phases : l'essai clinique, l'aperçu de l'essai et l'explication de l'échelle; les activités dynamiques; le groupe de discussion. Les participants ont coté, dans chaque exercice d'évaluation, les caractéristiques visuelles, l'acuité visuelle et l'acceptabilité des visières aux fins d'exécution des tâches.

On a appliqué un protocole d'essai progressif de quatre jours, comportant un banc d'essai statique à la phase 1, des essais dynamiques d'activités militaires distinctes à la phase 2 et, enfin, un essai dynamique de tâches militaires au combat à la phase 2B. À la phase 1, on a effectué des essais d'acuité visuelle. La phase 2 comprenait un parcours du combattant, un parcours en sentier boisé, un parcours en véhicule, un parcours de patrouille urbaine et un parcours de patrouille de nuit. La phase 3 comportait le combat dans les zones bâties. La collecte des données comprenait les mesures du rendement au niveau de la détection des cibles, les cotations de l'acceptabilité après chaque tâche, ainsi que les cotations de l'acceptabilité et le classement des préférences dans le questionnaire de départ. Après l'exécution de toutes les tâches avec les deux visières, les participants ont pris part à un groupe de discussion dirigé.

Les soldats ont jugé que la visière balistique d'épaisseur constante était beaucoup plus acceptable, et ils l'ont mieux cotée que la visière balistique d'épaisseur variable. Pour ce qui est de la tâche de patrouille de nuit, on n'a vu aucune différence importante entre les visières dans le rendement au niveau de la détection des cibles ou dans les cotations de l'acceptabilité indiquées dans le questionnaire.

D'après les résultats de cet essai, la visière balistique d'épaisseur constante offre une protection balistique acceptable de la partie supérieure du visage. Dans le cadre de la présente étude, les soldats ont déterminé qu'elle était plus acceptable dans l'ensemble que la visière balistique d'épaisseur variable concernant la majorité des critères. La visière balistique d'épaisseur constante était jugée plus acceptable et était mieux classée pour le parcours du combattant, le parcours en sentier boisé, le parcours en véhicule, la patrouille urbaine en véhicule, les opérations de nuit et les tâches de combat dans les zones bâties. On devrait, dans le cadre du projet *Habillez le soldat*, continuer à demander une visière balistique d'épaisseur constante en vue d'assurer la protection intégrée des yeux et de la partie supérieure visage.

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1. Background

1.1 Historical Eye Injury Perspective

Epidemiological data collected from various conflicts over the last 150 years, suggests that the incidence of eye and facial injuries is increasing and can account for a sizeable proportion of casualties (~12%) - see Figure 1 (Tack & Gaughan, 2000). This steady increase in eye injuries has been associated with the proliferation of fragmentation weapon use in urban and high mobility environments where the occurrence of high velocity, low mass primary and secondary fragments is high. Given the high vulnerability of the eye itself, even small fragments that are harmless to other areas of the body can readily produce ocular casualties.

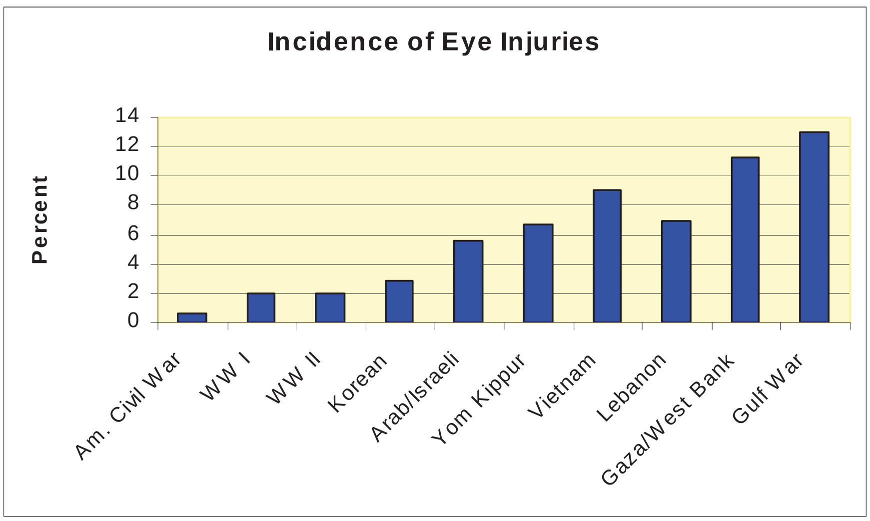


Figure 1: Historical Incidence of Eye Injury

With respect to eye injury during military operations, several studies describe similar outcomes. According to the Wong, Seet, and Ang (1997),

> *With successive wars in the twentieth century, there has been a relative increase in injuries to the eye compared to injuries of other parts of the body. The main causes of eye injury have changed with advances in techniques and weaponry of warfare, with blast fragmentation injuries accounting for 50-80% of cases. Penetrating and perforating injuries are most common, and injuries associated with intraocular foreign bodies pose special diagnostic and management problems. Injuries are bilateral in 15-25% of cases…However, prevention of injuries with eye armour is ultimately the best management, and the need for a comprehensive eye protection program in the military cannot be overemphasized, especially since eye injuries pose important socioeconomic, as well as medical, problems.*

Similarly Belkin, Treister, and Dotan (1984) holds,

> *There was a high incidence of ocular trauma (6.8% of all casualties) in the Lebanon War, 1982, which is similar to the rates in previous Arab-Israeli wars. Combat in the*

Lebanon War consisted of both armoured warfare and infantry operations, with much of the fighting taking place in built-up areas. Consequently, there were two main types of ocular injuries: perforating eye injuries caused by the small high-velocity missiles that characterize armoured combat, and a wide range of injuries to the eye caused by ricochets during combat in built-up areas... Not a single eye was injured in soldiers who had ballistic protective goggles properly placed over the eyes at the time of injury. Most of the ocular trauma could have been prevented had the goggles been in universal use.

In both cases, ballistic eye protection is the best method to lower the incidence of battlefield eye injuries.

1.2 Current Equipment

For general issue, Canadian Land Forces has procured ballistic protective spectacles as part of the Clothe the Soldier (CTS) Project. This ballistic eyewear (BEW) system improved individual protection by providing both ballistic and sun protection - see Figure 2. The ballistic eyewear incorporates corrective lenses for the approximately 42% of the Land Force who require prescription lenses (Tack & Gaughan, 2000).

The current BEW System is available in two sizes and the standard BEW issue includes:

- a green slim line frame with adjustable arms and two protective shields;
- a clear shield with integrated nosepiece used for night and low light levels;
- a solar shield with integrated nosepiece - used during the day (100% UV blockage);
- an adjustable elastic head strap to keep eyewear secure and stable during rigorous activity; and
- a green stowage case with anti-fog, anti-static cleaning kit.

(Fact Sheet: Ballistic Eyewear. (n.d.) Retrieved October 2, 2006)

*from http://www.army.forces.gc.ca/Chief_Land_Staff/Clothe_the_soldier/hab/PDF/FactSheets/BEW-fs_e.pdf

Figure 2: Current Ballistic Eyewear (BEW) Equipment

In an effort to provide increased ocular and facial protection of the soldier from ballistic threats, the Canadian Department of National Defence is also studying the feasibility of using visors.

1.3 General Purpose Visor Concepts

A four-day field trial was undertaken at CFB Petawawa over the period of 17 – 20 May 1999 to evaluate general purpose visor concepts (Tack & Gaughan, 2000). Twenty regular force infantry soldiers were required to undertake a battery of human factors tests while wearing up to four different visor conditions in a repeated measures design: two protection levels (V50 of 220 m/s and 450 m/s) and two shapes (flat and curved). All tests included a no visor condition as a baseline control. During each test, the order of conditions was balanced among participants. Human factors tests included clinical tests of visual performance, static military vision tests, performance of select obstacle course obstacles, range firing, battle tasks, equipment / weapons / vehicle compatibility clash, and maintainability.

During the trial, soldiers indicated that the most important assessment criteria for a general-purpose visor were weapon compatibility and visual performance (Tack & Gaughan, 2000). Visors posed a number of concerns in these areas. Participants rated visor use with the C7A1 rifle as unacceptable due to the slight delay necessary to position the nasal cut-out over the rifle butt to achieve a full sight picture. While annoying, participants quickly learned to adjust to the extra head movement needed during sighting to accommodate the visor. Visual performance was another concern among participants. Visual acuity tests confirmed that all of the visors tested produced a small but significant drop in visual performance. While participants did rate the visual performance aspects (e.g. visual sharpness, field of view, distortion, depth perception, etc.) of visors as low, the thin visors were generally rated significantly more favourably than the thick visor designs. In most evaluations, the thick visors were rated as unacceptable. In addition to the visual performance differences between the thin and thick visors, participants also noted additional musculoskeletal stress and fatigue at the neck associated with the higher load forces of the thick visors. Participants also expressed considerable concern about the ease with which an enemy observer might detect a highly reflective visor.

Only the thin visors were seen as an acceptable design solution for a general-purpose visor (Tack & Gaughan, 2000). For the thin visors, the curved design was preferred (78% of participants) to the flat design (22%). During focus group discussions, participants indicated that the curved thin visor would be suitable for driving vehicles, riot control or reaction to a hostile crowd, fighting in built up areas, and occupying a defensive position. Most participants (72%) would be willing to accept the curved thin visor for conventional warfare tasks if the concept of operations allowed them to raise the visor into a fixed "up" position when not in a threat situation and when using certain weapons (e.g. Carl Gustav). All participants agreed that general acceptance of any visor would improve with experience.

During the exit focus group discussions of the general purpose visor concept evaluation participants suggested that half-face coverage of the curved thin visor was considered acceptable for high activity tasks typical of conventional warfare (Tack & Gaughan, 2000). However, participants also stressed the need for more special-to-purpose variants to meet the range of task demands and threats possible in medium and low intensity conflicts. Examples included a full-face variant for riot control tasks and a selection of visors with different protective coatings (e.g. solar tinting, laser coatings).

1.4 Optically Corrected Visors

One of the concerns with ballistic visors was their optical performance. As stated in Hovis & Chou (1998) "One of the unresolved issues concerning visors is their level of optical quality.This issue is obviously important because if the soldiers cannot see adequately through the visor, then they will be reluctant to wear it." Hovis et al. developed a detailed set of optical requirements for a ballistic visor. Procedures

utilized for assessing visors used in industry, law enforcement and the military were exploited and draft requirements were proposed. Requirements were identified for the visor's primary visual field. This area is considered to be the useable viewing and all points within this area should fall within the recommended standards. Outside this area, the optical quality was assumed to be not as critical because it was thought that the user would rarely view through these extreme positions. Figure 3 shows the basic National Institute of Justice (NIJ) dimensions for a riot face shield which were used as the basis for defining the visual area in the Hovis et al. study.

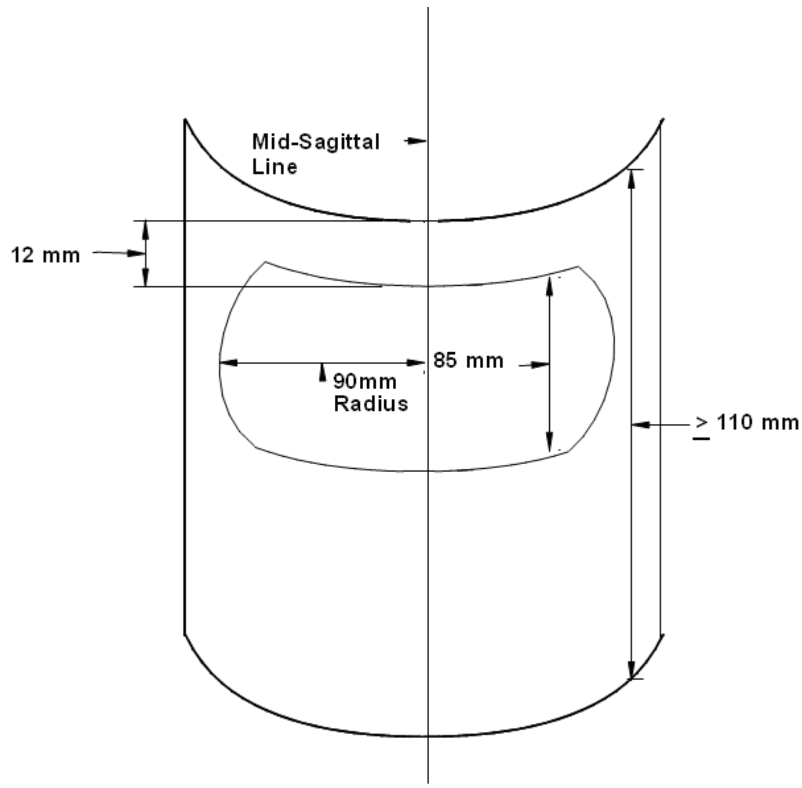


Figure 3: Basic dimensions of the primary visual area for a riot face shield as specified by the National Institute of Justice from (Hovis & Chou, 1998)

Hovis & Chou (1998) also indicated that an important influence on visor optical quality is the level of protection, since increase protection will increase thickness level required by the ballistic visor. The general expectation is that optical quality is degraded as visor thickness increase. Another parameter that influences optical performance is the shape of the visor since spherical visors in general have excellent optical quality in the straight-ahead position with degrading optical performance as the horizontal angle of incidence increases.

> *"Because the direction of vertical prism in front of each eye is usually the same for all visors, there is very little vertical imbalance induced, except at the extreme gazes. In contrast to vertical results, the amount of horizontal prism varies considerably across both to sampling position and thickness. This result is expected. Because the larger amounts and more variation of the horizontal prism, the resultant imbalance is also larger and more varied. One should also note the*

direction of the prism imbalance often changes when looking from area around the major reference point (MRP) to the extreme horizontal gazes. Soldier would adapt to this problem by making more head turns.

Hovis & Chou, 1998 (page 18)

In an effort to resolve horizontal prismatic imbalance issues, designers have developed means of manufacturing cylindrically shaped optically correct visors. One approach patented by Lori, Menta, Matteo, and Giani. (2005) utilizes the manufacture of a plano-convex optical sheet. The sheet thickness decreases along a portion of predetermined width of the optical sheet as it proceeds from the transversal central line to the lateral edges of the sheet. The result defines a convex outer surface having a curvature such that the optical sheet is capable of providing a cylindrically shaped optically correct visor once bent. Loriet al. (2005) suggest that a cylindrically shaped optically correct visor could improve visual performance for off-center gazes.

In an effort to increase ballistic protection for its soldiers, the Canadian Forces has developed two ballistic visor designs for user evaluations; a constant thickness visor and a variable thickness visor.

2. Aim

The purpose of this trial was to evaluate the impact of variable thickness and constant thickness ballistic visors on human performance measures for both task performance and visual characteristics with the intention of determining which visor will best support Canadian Forces operations. Specifically, this study sought to determine if there were significant differences between the two visors. Visual performance in both day light and night time conditions were evaluated for variable thickness and constant thickness ballistic visors.

3. Method

The following description provides a general overview of the trial method. Further details are provided in subsequent sections.

3.1 Overview

A four-day field trial was undertaken at CFB Edmonton over the period of June 12 - 16, 2006. Twenty regular (n=5) and reserve (n=15) force infantry soldiers of various Canadian units were required to undertake a battery of human factors tests while wearing two different ballistic visor conditions in a repeated measures design of the two designs. The order of exposure to each visor condition was balanced among participants.

The tests progress from static test stands in Stage 1, to dynamic discrete military activities test stands in Stage 2, and dynamic military battle tasks in Stage 3. Stage 1 was acuity testing. Stage 2 included an obstacle course, a wooded lane course, a vehicle course, an urban patrol course, and a night operations course. Stage 3 involved Fighting In Built Up Areas (FIBUA) tasks.

Human factors (HF) measures assessed the task acceptability, acceptability of visual performance, and overall acceptability. Data collection included daily task questionnaires, an exit questionnaire, focus groups, performance measures, and HF observer assessments.

3.2 Visor Conditions Evaluated

The Clothe the Soldier ballistic visor is being introduced into the Land Forces to provide soldiers increased protection from improvised explosive devices (IEDs) when conducting relatively static activities. As part of the development process, two visor designs were created in an effort to minimize any negative optical effects introduced by the visor. This trial investigated two non-prescription ballistic visors; one of continuous thickness and one of variable thickness. The two visor designs are described below: - see Figure 4.

a) **Constant Thickness Visor.** The constant thickness visor has a thickness of 6.5mm along the entire visor curvature and is the simplest design. This design provides excellent protection without imposing a great deal of technical difficulties in the manufacturing process. Due to thickness of the visor medium, optical performance is a concern, in particular prismatic deviation is high. Since soldiers have a tendency to focus directly on objects in their field of view, it is uncertain of this will pose significantly ill effects

b) **Variable Thickness Visor.** The variable thickness visor has a central thickness of 7.4mm and tapers to 6.5mm at the sides. As such, it does not have a constant thickness across its entire surface. This theoretical design was chosen to optimize optical performance in an effort to reduce the effects of distortion and prismatic deviation. There are significant technical challenges in the manufacturing process of this visor, which may hinder the ability to achieve the theoretically calculated optimal design. As such it is uncertain if this design will increase the soldier's visual performance.

Figure 4: Ballistic Visors

3.3 Trial Participants

Seventeen male and three female soldiers, both regular and reserve force, were recruited for this experiment from various units. The mean age of the participants was 22.4 years (SD= 4.0, max= 33, min= 18). The mean length of service for the five regular force participants was 5.3 years (SD= 3.5, max= 10.5, min= 2). The mean length of service for the fifteen reserve force participants was 3.0 years (SD= 1.8, max= 7.5, min= 1). Twenty-five percent of the participants wore glasses. During the trial these participants wore corrective contact lenses.

The participants were organized into two groups of 10 soldiers for the purpose of the trial (e.g. Sections A and B). Two senior non-commissioned officers (NCOs) were required to act as Section Commanders throughout the trial. The Section Commanders also served as participants in the trial.

3.4 Measures

The study included objective measures and qualitative assessments. The data tools are described in greater detail below.

3.4.1 Objective Assessments

Visual acuity screening assessments: Visual acuity of each participant (right and left eye) was measured using a Snellen chart. Participants were also assessed for stereoacuity using the Randot ® Stereo Test from Stereo Optical Company, Inc, Chicago, IL. Interpupillary distances were also assessed using a clear ruler with a mm scale. Visual assessments were performed by a Subject Matter Expert (SME) from the School of Optometry University of Waterloo to assess the soldiers' baseline visual acuity and stereoacuity. No visual acuity and stereoacuity screening was performed with the visors.

Target detection performance: The number of targets detected was recorded manually for the wooded, vehicle and urban lane courses.

3.4.2 Questionnaires

Participants completed a number of questionnaires designed to reveal their perceptions of the acceptability

of the ballistic visors for each task.

The task acceptability questionnaire was used to obtain immediate feedback, while the exit questionnaire gathered opinions of the participants following all of the evaluation exercises. Visor acceptability was surveyed on the following human factors criteria:

- Visual characteristics
  - Sharpness, distortion, field of view, depth perception, glare, blind spot, fogging
  - Eye fatigue, headaches, nausea
- Visual acuity
  - Target detection far, target detection near, object acuity
- Task performance
  - Obstacle traverse, FIBUA, patrolling, urban vehicle patrol, night operations

The participants rated the acceptability of the ballistic visors for each of the criteria on a 7-point rating scale, where 1 was completely unacceptable, 4 was borderline, and 7 was completely acceptable - see Figure 5.

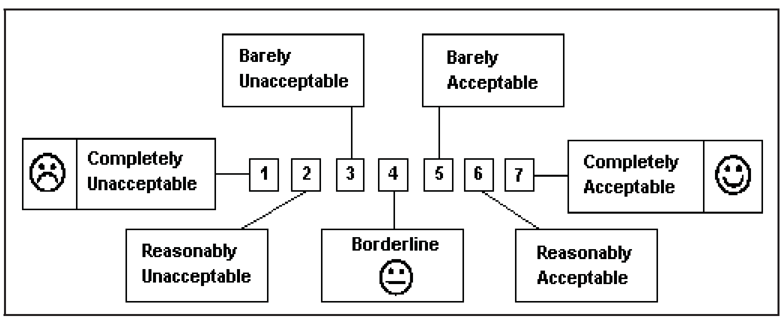


Figure 5: Standard Seven-Point Rating Scale of Acceptance

Target detection performance was also recorded for the wooded lane course, vehicle course, and night operation course. Participants indicated when and where a target was detected to a data collector for both the wooded lane course and vehicle lane course. Participants were required to document the location of targets seen on a map provided for the night operation course.

As a part of the exit questionnaire, participants also ranked each ballistic visor in order of merit for visual characteristics, visual acuity, and task performance criterion. Visors were ranked in order of preference where a 1 was for the visor which performed the best and a 2 would indicate the ballistic visor that performed the worst. Participants would indicate visor rank ties with any particular criterion by scoring both visors as 1.

3.4.3 Focus Group

Following the completion of all tasks for both ballistic visors, participants took part in a guided focus group to discuss the merits and weaknesses of each ballistic visor.

3.4.4 Statistical Analysis

Repeated measures ANOVA were conducted for all subjective acceptability rating and performance data. Significant differences for rank order data were analyzed using non-parametric Wilcoxon matched pairs analysis. Statistically significant differences are reported at $p<0.05$. Sample sizes varied throughout the study due to participant availability to answer criteria. Individual sample sizes are reported for each set of analyses.

3.5 Experimental Schedule

The trial was conducted over the course of four days: trial overview, scale explanation, and clinical testing (day one); dynamic activities (day two and three); and focus group (day four).

Day one: On day one, the HF experimenters briefed the participants on the purpose of the trial, test activities, data collection tools, and equipment. Participants were also briefed on the various types of questions they would be required to answer and the procedures for filling in the questionnaires. All participants then underwent visual acuity testing. Participants were then randomly assigned one of two visors, with the order of conditions balanced among participants. Balancing participants ensured that equal proportions of each visor were present on each day to control for both learning and environment effects.

Day two and three: On the morning of day two and three, participants were split into two groups. One group completed FIBUA and an obstacle course while the other group completed the vehicle course. The groups would switch later in the morning and completed the other activities. Task questionnaires were completed for each task. In the afternoon, one group of participants completed the wooded lane while the other group completed the urban patrol course task. The groups switched tasks later in the afternoon and completed other task. Again, acceptability data was gathered by task questionnaires. During the nights of day two and three, participants completed a night operations course. Task questionnaires were used to collect acceptability data.

Participants evaluated one visor on day two and the other visor on day three.

Day Four: In the morning, the participants completed an acceptability rating and ranking exit questionnaire followed by a guided focus group. The focus group allowed discussion of the good and bad points of each visor in an open forum.

3.6 Experimental Protocol

The framework for progressive testing in the visor trial is outlined in Figure 6 (test descriptions are provided in section 3.4). Stage 1 began with clinical tests to determine the level of visual acuity of participants. Stage 2 included the human factors performance test stands. The tests progress from static acuity test stands in Stage 1, to dynamic discrete military activity courses in Stage 2 and finally dynamic military battle tasks in stage 2B.

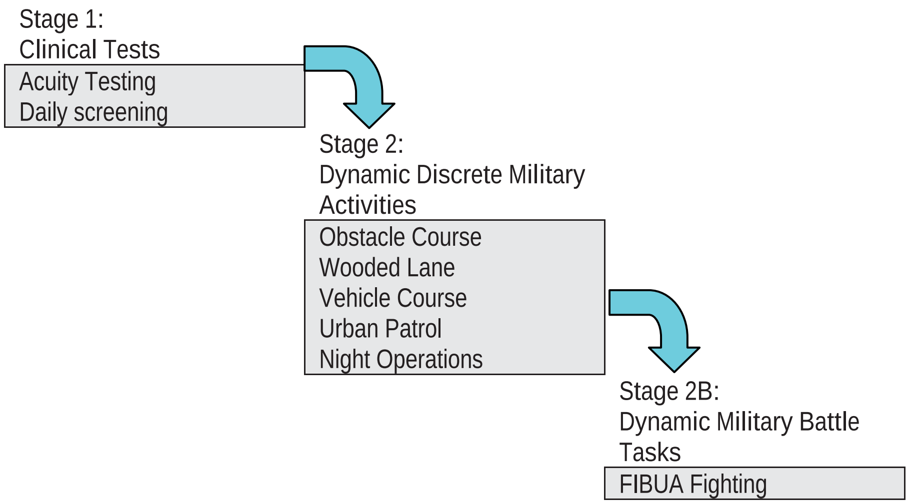


Figure 6: Progressive Testing Protocol

Stage 1 involved a test stand that assessed the soldiers' visual acuity, stereoacuity and introduced the participants to rating nausea, eye fatigue and headache issues before testing - see Figure 7 and Figure 8.

Figure 7: Visual Acuity Testing

Figure 8: Randot ® Stereoacuity Testing **(from http://www.stereooptical.com/MainPages/Randot.htm)**

Stage 2 tests incorporated dynamic movement and discrete military activities. The obstacle course

assessed the visual aspects of the different designs during obstacle traversing manoeuvres with the head oriented in a wide range of postures - see Figure 9. The wooded lane, vehicle course, urban vehicle patrol and night operations assessed typical field movements and allowed limited time to acquire targets. The task during the wooded lane course was detecting 10 partially occluded, time limited, off-axis targets at 10 to 75 meters from the participant - see Figure 10. The vehicle course assessed the task of detecting 10 partially occluded, time limited, off-axis targets at 50 to 250 meter distances from the participant - see Figure 11. The urban vehicle patrol assessed target detection of one or two marked vehicles at distances of 50 to 100 meters in a visually cluttered environment - see Figure 12. The night operation course task was detecting 10 partially occluded, off-axis targets at 10 to 75 meters from the participant - see Figure 13. Patrols were performed to simulate the visual demands of patrolling and target detection of an enemy force. Night patrolling added effects of glare of street lighting, reduced ambient illumination, and reduced contrast.

Figure 9: Obstacle Course

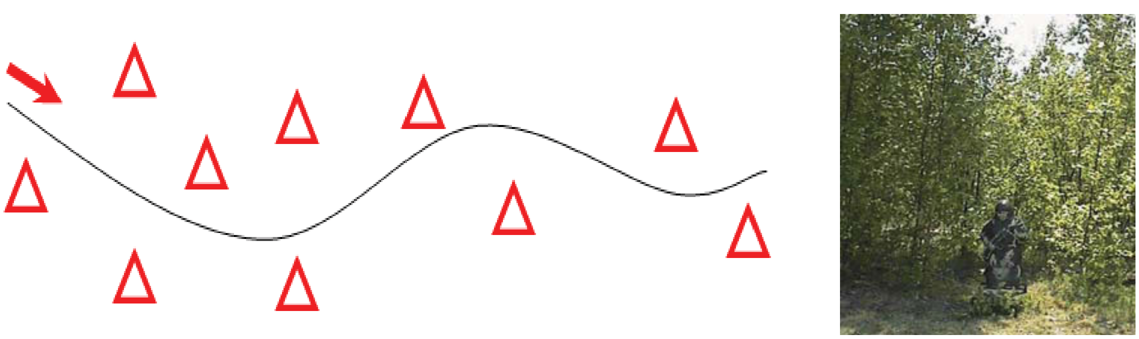


Figure 10: Wooded Lane Course

Figure 11: Vehicle Lane Course

Figure 12: Urban Vehicle Patrol Course

Figure 13: Night Patrol Course

Finally, Stage 2B built on all previous stages by performing infantry FIBUA battle tasks, which combine many infantry activities and skills into high fidelity simulations of combat missions - see Figure 14. Day time FIBUA section attacks were performed to simulate the visual demands of contact engagements with an enemy force with the added effects of reduced ambient illumination and contrast when transitioning from outside to inside conditions. These simulations were critical given the importance of ocular protection and task compatibility for FIBUA battle tasks.

Figure 14: FIBUA Section Attacks

4. Results

In the following sections, means and standard deviations are presented for the questionnaire data. These include participant's assessment of the acceptability of visual characteristics, visual acuity, and task performance.

Most participants had no previous experience with visors in section and platoon assaults. Furthermore, most participants had no previous experience working together as a team. Total exposure time to each visor was a single day (approximately 8 to 9 hours).

The ballistic visor induces limited visual distortion due to lens dynamics (thickness of the lens causes vision distortion). The effects of this visual distortion on target engagement was not evaluated. Therefore the impact each ballistic visor design has on the soldier ability to engage targets could not be evaluated in this trial.

Recall, visual acuity testing was carried out on the first day of this trial. The task questionnaire was completed after each task was performed throughout the trial, whereas rating acceptability and rank exit questionnaires were completed at the end of this trial after all tasks were performed with both ballistic visors. Finally, a summary of the focus group discussions is presented.

4.1 Visual Acuity Assessment

During a first day of the trial, participants were screened for visual acuity. An acuity chart mounted on a well-lit wall was used to test participants for visual acuity. The scientific authority in vision conducted the screening. The mean readings for the twenty individuals are detailed in Table 1.

Table 1: Acuity Assessment Results

	Mean	Standard Deviation
Right Eye Visual Acuity (logMAR)	-0.056	0.091
Left Eye Visual Acuity (logMAR)	-0.058	0.102
Stereo Acuity (Min arc)	43.158	4.776
Interpupillary Distance (mm)	62.800	2.215

With a visual acuity benchmark of maximum one error on the 6/6 line allowed, only 3 subjects failed in either eye. For stereo acuity a value greater than 60 or none would be considered to be abnormal. Only one person did not meet this stereo acuity standard.

4.2 Task Acceptability

Participants rated the acceptability of the two ballistic visor designs in six activities. These included an obstacle course, wooded lane course, vehicle course, urban vehicle patrol course, night patrol operations, and FIBUA. Results of acceptability of each ballistic visor for the six activities are detailed below.

4.2.1 Obstacle Course

Visual characteristics and task performance were investigated for both ballistic visor designs. These included visual characteristics such as sharpness, distortion, field of view, depth perception, nausea, glare, visual sharpness, fogging, eye fatigue, headaches; task performance such as day tasks, obstacle traverse, walking, running; and overall acceptability. Results from the obstacle course are presented in Table 2,

with significant differences indicated in bold text.

Table 2: Obstacle Course Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	5.8 (1.0)	4.2 (1.3)	F(1, 19)=19.15, p=0.00032
Field of view	6.0 (1.1)	5.3 (1.3)	F(1, 19)=7.12, p=0.01519
Depth perception	5.9 (1.2)	3.9 (1.5)	F(1, 19)=23.84, p=0.00010
Nausea	6.6 (0.8)	5.6 (1.9)	F(1, 19)=3.89, p=0.06326
Visual glare/haze	5.9 (1.1)	5.6 (1.1)	F(1, 19)=1.43, p=0.24646
Visual sharpness (side)	5.8 (1.2)	5.1 (1.2)	F(1, 19)=5.12, p=0.03556
Visual sharpness (fwd)	6.2 (0.9)	5.3 (1.3)	F(1, 19)=8.60, p=0.00855
Fog due to environment	5.9 (1.1)	5.8 (1.7)	F(1, 19)=0.91, p=0.35205
Fog due to workload	5.0 (1.4)	5.2 (1.6)	F(1, 18)=0.014, p=0.90798
Eye fatigue	6.6 (0.7)	5.2 (2.0)	F(1, 19)=7.81, p=0.01155
Headaches	6.6 (0.7)	6.2 (0.9)	F(1, 19)=1.51, p=0.23445
Task Performance			
Day tasks	6.0 (0.6)	5.3 (1.2)	F(1, 16)=6.94, p=0.01804
Obstacle traverse	5.9 (0.8)	4.9 (1.3)	F(1, 16)=5.61, p=0.03077
Walking	6.3 (0.9)	5.8 (1.1)	F(1, 9)=0.37, p=0.55986
Running	5.8 (0.9)	5.2 (1.4)	F(1, 18)=2.89, p=0.10613
Overall			
Visual characteristics	6.1 (0.6)	4.8 (1.4)	F(1, 19)=18.70, p=0.00037
Task performance	5.9 (0.8)	4.7 (1.3)	F(1, 19)=9.94, p=0.00524
Overall acceptability	6.0 (0.6)	4.7 (1.4)	F(1, 19)=13.96, p=0.00140

A significant effect was observed between the two visors in terms of the overall ability to perform obstacle course tasks. The constant thickness ballistic visor was rated significantly more acceptable than the variable thickness ballistic visor for the majority of questions. For the constant thickness ballistic visor, the mean participant rating was “reasonably acceptable” while for the variable thickness ballistic visor the mean ratings were “borderline” to “barely acceptable” for the obstacle course.

4.2.2 Wooded Lane

From the wooded lane course, target detection performance and participant acceptability ratings were collected. Figure 15 presents the number of targets detected for each visor condition. On average, participants detected 8.2 targets in the constant thickness visor condition and 7.7 targets in the variable thickness visor condition. No significant difference (F(1,32) = 1.4449 p=0.29263) was observed in the number of targets detected by the participants in each visor condition. Participant ratings of acceptability for each of the ballistic visor designs are presented in Table 3, with significant differences indicated in bold text.

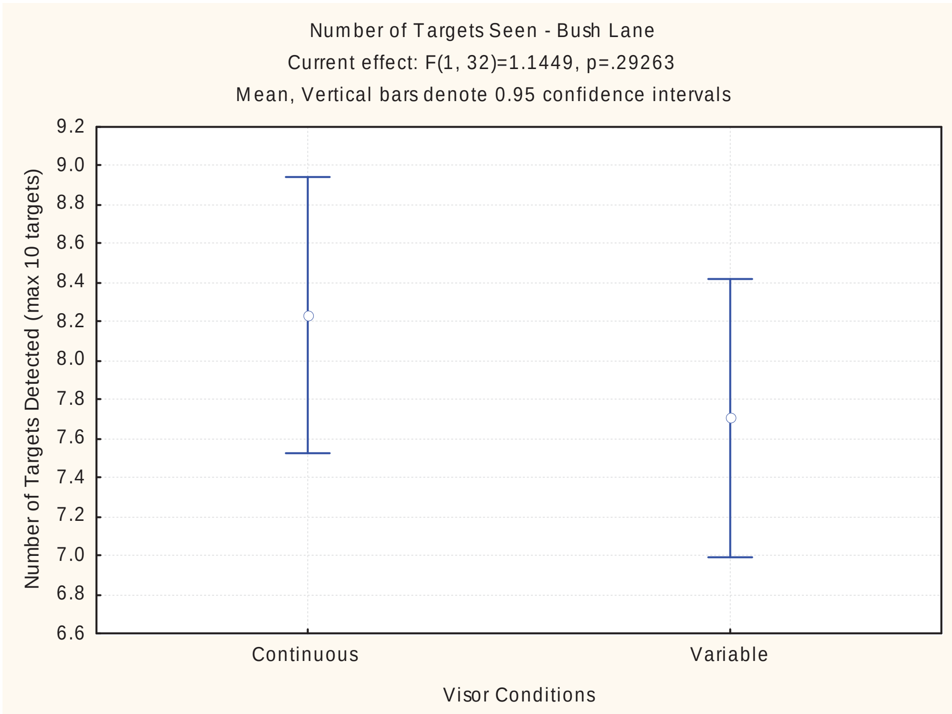


Figure 15: Number of Targets Detected on Wooded Lane Course

Table 3: Wooded Lane Course Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	6.1 (0.8)	4.5 (1.4)	F(1, 16)=13.19, p=.00224
Field of view	5.9 (0.7)	5.0 (1.7)	F(1, 16)=5.13, p=.03771
Depth perception	6.0 (0.9)	4.7 (1.7)	F(1, 16)=10.005, p=.00603
Nausea	6.8 (0.6)	5.8 (1.7)	F(1, 16)=6.48, p=.02163
Visual glare/haze	6.2 (0.8)	5.2 (1.6)	F(1, 16)=10.46, p=.00519
Visual sharpness (side)	5.9 (0.9)	4.7 (1.6)	F(1, 16)=9.21, p=.00788
Visual sharpness (fwd)	6.2 (0.9)	5.1 (1.4)	F(1, 16)=8.10, p=.01167
Fog due to environment	5.9 (0.9)	4.4 (2.1)	F(1, 16)=13.19, p=.00224
Fog due to workload	6.1 (0.7)	5.1 (1.5)	F(1, 16)=5.23, p=.03615
Eye fatigue	6.5 (0.8)	5.0 (1.6)	F(1, 16)=14.62, p=.00150
Headaches	6.8 (0.4)	5.4 (1.8)	F(1, 15)=9.92, p=.00662
Task Performance			
Target detection far	6.1 (1.0)	4.8 (1.9)	F(1, 16)=7.03, p=.01743
Target detection near	6.4 (0.9)	5.5 (1.5)	F(1, 16)=5.06, p=.03895
Target detection (front)	6.4 (0.8)	5.4 (1.4)	F(1, 16)=6.89, p=.01835
Target detection (sides)	5.8 (1.1)	4.8 (1.9)	F(1, 16)=5.99, p=.02635
Day tasks	6.2 (0.7)	5.3 (1.5)	F(1, 15)=4.69, p=.04678
Jungle/wood lane	6.1 (1.0)	5.1 (1.7)	F(1, 14)=2.01, p=.17807
Walking	6.5 (0.6)	5.4 (1.7)	F(1, 14)=9.64, p=.00775
Overall			
Visual characteristics	6.0 (0.8)	5.0 (1.4)	F(1, 16)=7.16, p=.01659
Task performance	5.6 (1.4)	4.8 (1.7)	F(1, 16)=6.48, p=.02160
Overall acceptability	6.0 (0.9)	4.8 (1.6)	F(1, 16)=8.46, p=.01025

A significant effect was observed between the two visors in terms of the overall acceptability for the wooded lane course. The constant thickness ballistic visor was rated significantly higher in acceptability than the variable thickness ballistic visor for the majority of questions. Participants rated the constant thickness ballistic visor “barely acceptable” to “reasonably acceptable” and the variable thickness ballistic visor “borderline” to “barely acceptable”. While no performance difference between the visors was observed in number of targets detected, in general participants strongly preferred the constant thickness visor for the wooded lane course.

4.2.3 Vehicle Course

From the vehicle course, target detection performance and participant acceptability ratings were collected. Figure 16 presents the number of targets detected for each visor condition. On average, participants detected 6.6 targets in the constant thickness visor condition and 6.9 targets in the variable thickness visor condition. No significant difference ($F(1,15)=0.47038$, $p=0.50327$) was observed in the number of targets detected by the participants in each visor condition. Participant ratings of acceptability for each of the ballistic visor designs are presented in Table 4, with significant differences indicated in bold text.

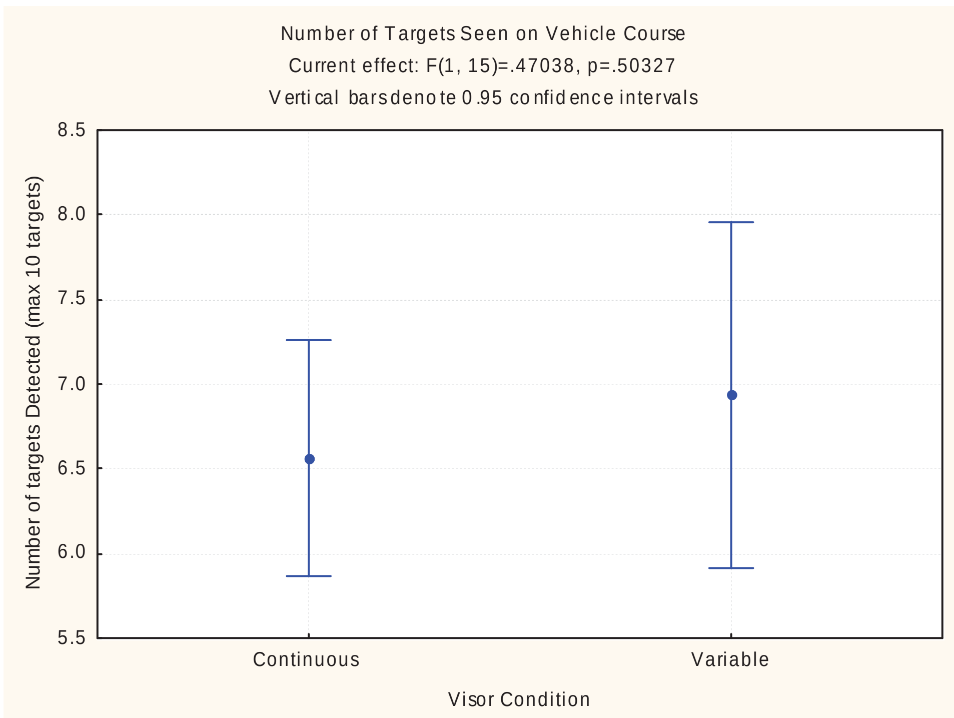


Figure 16: Number of Targets Detected on Vehicle Course

Table 4: Vehicle Course Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	6.3 (0.6)	4.9 (1.2)	F(1, 17)=15.42, p=.00109
Field of view	6.2 (0.7)	5.6 (0.9)	F(1, 17)=6.18, p=.02360
Depth perception	6.3 (0.7)	4.8 (1.2)	F(1, 17)=28.10, p=.00006
Nausea	6.8 (0.4)	5.4 (1.5)	F(1, 17)=14.65, p=.00135
Visual glare/haze	6.1 (0.9)	5.6 (1.0)	F(1, 17)=3.73, p=.07023
Visual sharpness (side)	6.0 (0.8)	5.1 (1.2)	F(1, 17)=13.60, p=.00183
Visual sharpness (fwd)	6.4 (0.8)	5.4 (0.8)	F(1, 17)=22.81, p=.00018
Fog due to environment	6.6 (0.6)	6.2 (0.8)	F(1, 17)=1.70, p=.20967
Fog due to workload	6.4 (0.5)	6.1 (0.9)	F(1, 15)=2.87, p=.11077
Eye fatigue	6.4 (0.7)	5.2 (1.7)	F(1, 17)=8.00, p=.01157
Headaches	6.6 (0.6)	5.7 (1.3)	F(1, 17)=6.40, p=.02159
Task Performance			
Target detection far	6.1 (0.7)	5.3 (1.4)	F(1, 17)=6.36, p=.02195
Target detection near	6.4 (0.8)	5.8 (0.8)	F(1, 17)=4.21, p=.05597
Target detection (front)	6.4 (0.5)	5.9 (0.9)	F(1, 17)=6.12, p=.02421
Target detection (sides)	6.0 (0.5)	5.2 (1.2)	F(1, 17)=14.65, p=.00135
Day tasks	6.4 (0.5)	5.7 (1.1)	F(1, 15)=6.50, p=.02217
Vehicle course	6.3 (0.6)	5.6 (0.8)	F(1, 17)=13.75, p=.00175
Overall			
Visual characteristics	6.2 (0.6)	5.3 (0.9)	F(1, 17)=14.66, p=.00135
Task performance	6.3 (0.5)	5.6 (0.8)	F(1, 17)=9.71, p=.00627
Overall acceptability	6.2 (0.5)	5.2 (1.3)	F(1, 17)=9.43, p=.00692

A significant effect was observed between the two visors in terms of the overall acceptability of the visor for the vehicle course task. The constant thickness ballistic visor was rated significantly higher in acceptability than the variable thickness ballistic visor for the majority of questions. In general, participants favoured the constant thickness ballistic visor design over the variable thickness ballistic visor for the vehicle course. The constant thickness visor was rated "reasonably acceptable" and the variable thickness visor was rated between "borderline" and "reasonably acceptable". While no performance difference between the visors was observed in number of targets detected, in general participants strongly preferred the constant thickness visor for the vehicle course.

4.2.4 Vehicle Urban Patrol

Results from the vehicle urban patrol are presented in Table 5, with significant differences indicated in bold text.

Table 5: Vehicle Urban Patrol Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	6.3 (0.5)	4.9 (1.0)	F(1, 15)=22.60, p=.00026
Field of view	6.2 (0.7)	5.7 (1.0)	F(1, 15)=5.00, p=.04097
Depth perception	6.3 (0.6)	4.9 (1.2)	F(1, 15)=14.29, p=.00181
Nausea	6.8 (0.4)	5.9 (1.3)	F(1, 15)=5.99, p=.02715
Visual glare/haze	6.3 (0.6)	5.5 (1.0)	F(1, 15)=12.74, p=.00280
Visual sharpness (side)	6.1 (0.7)	5.1 (1.4)	F(1, 15)=15.99, p=.00116
Visual sharpness (fwd)	6.4 (0.5)	5.3 (1.2)	F(1, 15)=15.38, p=.00136
Fog due to environment	6.4 (0.5)	6.1 (1.2)	F(1, 14)=1.09, p=.31336
Fog due to workload	6.4 (0.5)	6.2 (1.1)	F(1, 13)=0.51, p=.48738
Eye fatigue	6.4 (0.6)	4.7 (1.4)	F(1, 14)=21.81, p=.00036
Headaches	6.5 (0.8)	5.3 (1.3)	F(1, 14)=7.99, p=.01343
Task Performance			
Target detection far	6.1 (0.7)	4.7 (1.4)	F(1, 13)=15.27, p=.00180
Target detection near	6.3 (0.7)	5.5 (1.2)	F(1, 13)=8.27, p=.01299
Target detection (front)	6.5 (0.6)	5.6 (1.2)	F(1, 13)=15.13, p=.00186
Target detection (sides)	6.1 (0.6)	4.8 (1.5)	F(1, 13)=17.43, p=.00109
Day tasks	6.4 (0.5)	5.8 (0.7)	F(1, 12)=11.64, p=.00516
Urban vehicle patrol	6.4 (0.5)	5.5 (1)	F(1, 14)=10.02, p=.00687
Overall			
Visual characteristics	6.2 (0.4)	5.3 (0.8)	F(1, 15)=19.29, p=.00053
Task performance	6.4 (0.6)	5.6 (0.8)	F(1, 15)=12.74, p=.00280
Overall acceptability	6.3 (0.5)	5.2 (1.0)	F(1, 15)=15.38, p=.00136

A significant effect was observed between the two visors in terms of the overall acceptability for the vehicle urban patrol task. The constant thickness ballistic visor was rated significantly higher in acceptability than the variable thickness ballistic visor for the majority of questions.

On the whole for the vehicle urban patrol task, participants favoured the constant thickness ballistic visor design over the variable thickness ballistic visor. The constant thickness ballistic visor was rated "reasonably acceptable" while the variable thickness ballistic visor was rated between "borderline" to "reasonably acceptable".

4.2.5 Night Patrol

From the night patrol, target detection performance and participant acceptability ratings were collected. Figure 17 presents the number of targets detected for each visor condition. On average, participants detected 5.4 targets in the constant thickness visor condition and 5.1 targets in the variable thickness visor condition. No significant difference (F(1, 18) =0.54988, P=0.46793) was observed in the number of targets detected by the participants in each visor condition. Participant ratings of acceptability for each of the ballistic visor designs are presented in Table 6, with significant differences indicated in bold text.

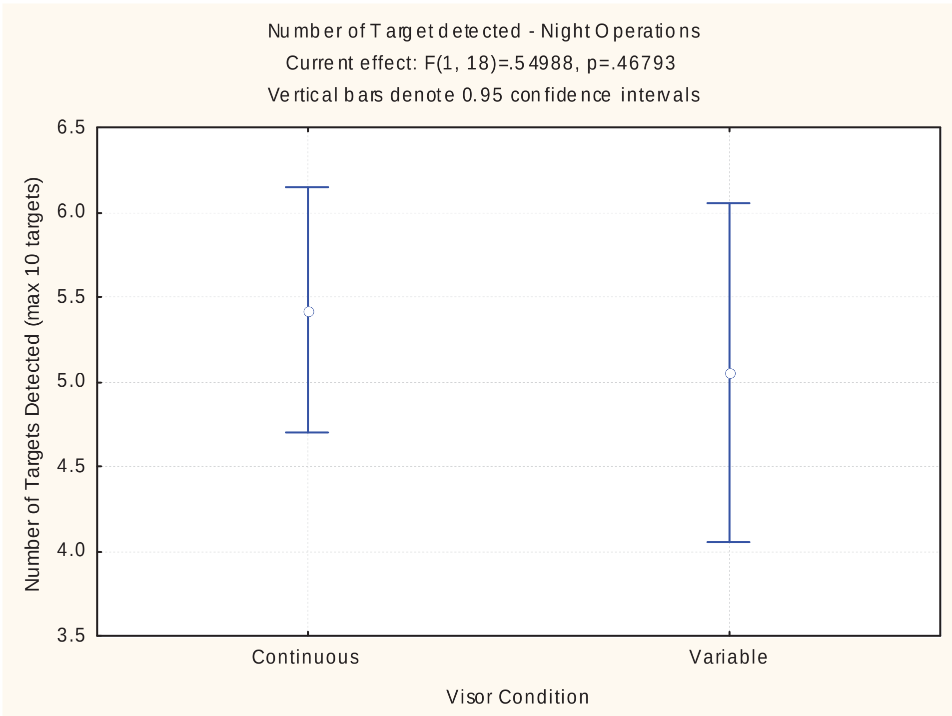


Figure 17: Number of Targets Detected on Night Patrol Course

Table 6: Night Patrol Course Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	5.9 (1.2)	4.0 (1.5)	F(1, 18)=18.81, p=.00040
Field of view	6.2 (0.8)	4.7 (1.9)	F(1, 18)=13.64, p=.00166
Depth perception	6.0 (1.1)	4.9 (1.4)	F(1, 18)=10.26, p=.00493
Nausea	6.5 (0.8)	5.8 (1.8)	F(1, 18)=3.19, p=.09070
Visual glare/haze	4.5 (2.0)	3.9 (1.7)	F(1, 18)=0.78, p=.38815
Visual sharpness (side)	5.9 (1.2)	4.7 (1.4)	F(1, 18)=11.10, p=.00371
Visual sharpness (fwd)	6.1 (0.8)	4.9 (1.4)	F(1, 18)=15.02, p=.00111
Fog due to environment	6.5 (0.9)	6.5 (0.8)	F(1, 17)=0.00, p=1.0000
Fog due to workload	6.2 (1.0)	6.6 (0.7)	F(1, 15)=1.22, p=.28748
Eye fatigue	5.9 (1.8)	4.7 (2.3)	F(1, 18)=4.47, p=.04866
Headaches	6.3 (1.0)	5.9 (1.5)	F(1, 18)=2.94, p=.10364
Task Performance			
Target detection far	5.3 (1.8)	4.7 (1.6)	F(1, 18)=0.72, p=.40581
Target detection near	6.5 (0.6)	5.8 (1.3)	F(1, 18)=4.80, p=.04186
Target detection (front)	6.4 (0.7)	5.6 (1.3)	F(1, 18)=5.86, p=.02628
Target detection (sides)	5.8 (1.2)	5.1 (1.3)	F(1, 17)=5.39, p=.03293
Walking	6.3 (0.5)	5.6 (1.2)	F(1, 17)=5.78, p=.02788
Twilight tasks	5.8 (0.9)	4.4 (2.0)	F(1, 5)=0.36, p=.57613
Night tasks	5.4 (1.3)	4.8 (1.7)	F(1, 16)=1.30, p=.27010
Overall			
Visual characteristics	5.7 (1.0)	5.1 (1.0)	F(1, 17)=2.96, p=.10368
Task performance	5.6 (1.1)	5.3 (1.1)	F(1, 17)=1.91, p=.18527
Overall acceptability	5.7 (1.1)	5.2 (1.0)	F(1, 17)=3.15, p=.09383

No significant effect was observed between the two visors in overall acceptability for the night patrol task (F(1, 17)=3.1501, p=.09383). However, the constant thickness ballistic visor was rated significantly higher in acceptability than of variable thickness ballistic visor for some of the criteria. For both visor conditions, participants tended to give ratings of "borderline" to "reasonably acceptable".

4.2.6 FIBUA

Results from the FIBUA assault are presented in Table 7, with significant differences indicated in bold text.

Table 7: FIBUA Visor Acceptability Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	6.2 (0.7)	5.0 (1.2)	F(1, 16)=9.79, p=.00648
Field of view	6.4 (0.5)	5.0 (1.7)	F(1, 16)=11.89, p=.00331
Depth perception	6.3 (0.6)	4.6 (1.6)	F(1, 16)=16.81, p=.00084
Nausea	6.7 (0.6)	5.8 (1.6)	F(1, 16)=6.19, p=.02428
Visual glare/haze	6.0 (1.1)	5.2 (1.7)	F(1, 16)=4.79, p=.04370
Visual sharpness (side)	6.0 (0.8)	4.8 (1.6)	F(1, 16)=10.92, p=.00447
Visual sharpness (fwd)	6.4 (0.7)	5.4 (1.4)	F(1, 16)=7.56, p=.01427
Fog due to environment	6.2 (0.9)	5.4 (1.6)	F(1, 16)=3.89, p=.06662
Fog due to workload	5.5 (1.1)	5.4 (1.4)	F(1, 16)=0.16, p=.69315
Eye fatigue	6.4 (0.9)	4.6 (2.0)	F(1, 16)=13.30, p=.00218
Headaches	6.6 (0.5)	5.0 (1.5)	F(1, 15)=17.26, p=.00085
Task Performance			
Target detection far	6.4 (0.5)	5.0 (2.0)	F(1, 6)=4.033, p=.09137
Target detection near	6.6 (0.6)	5.5 (1.4)	F(1, 15)=6.67, p=.02083
Target detection (front)	6.5 (0.6)	5.8 (1.4)	F(1, 15)=3.03, p=.10220
Target detection (sides)	5.9 (1.2)	5.1 (1.6)	F(1, 15)=7.74, p=.01397
FIBUA assault	5.8 (1.0)	5.6 (0.8)	F(1, 14)=1.67, p=.21697
Walking	6.3 (0.7)	5.6 (1.4)	F(1, 13)=5.64, p=.03365
Running	6.0 (0.8)	5.0 (1.2)	F(1, 12)=9.75, p=.00881
Overall			
Visual characteristics	6.0 (0.9)	4.9 (1.3)	F(1, 16)=7.10, p=.01695
Task performance	5.8 (1.3)	5.3 (1.4)	F(1, 16)=2.98, p=.10373
Overall acceptability	6.0 (0.7)	4.9 (1.5)	F(1, 16)=9.86, p=.00634

A significant effect was observed between the two visors in terms of the overall acceptability for the FIBUA task (F(1, 16)=9.8555, p=.00634). The constant thickness ballistic visor was significantly more acceptable than the variable thickness ballistic visor for the majority of questions. In general for the FIBUA task, participants preferred the constant thickness ballistic visor design over the variable thickness ballistic visor. The constant thickness ballistic visor was rated from "barely acceptable" to "reasonably acceptable", while the variable thickness ballistic visor was rated from "borderline" to "barely acceptable".

4.2.7 Exit Questionnaire

Visual characteristics and task performance were surveyed for both visor designs. These included visual characteristics such as sharpness, distortion, field of view, depth perception, nausea, glare, visual sharpness, fogging, eye fatigue, headaches and blind spots; visual acuity characteristics such as the detection of large objects, small objects, low contrast objects, target detection; task performance such as day operations, night operations; and overall. Recall that exit questionnaires were completed at the end of the trial after all tasks were performed with both ballistic visors. The participant ratings of acceptability of

both visor designs are presented in Table 8 and rankings are presented in Table 9.

Table 8: Exit Questionnaire Acceptability Rating Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	6.1 (0.6)	3.7 (1.7)	F(1, 19)=33.78, p=.00001
Depth perception	6.1 (0.7)	3.6 (1.5)	F(1, 19)=48.50, p=.00000
Nausea	6.7 (0.6)	5.3 (2.0)	F(1, 19)=11.59, p=.00298
Eye fatigue	6.4 (0.8)	3.8 (2.2)	F(1, 19)=24.99, p=.00008
Headaches	6.5 (0.8)	4.5 (2.2)	F(1, 19)=14.90, p=.00105
Visual glare/haze	5.5 (1.4)	4.7 (1.9)	F(1, 19)=2.99, p=.09973
Visual sharpness (side)	6.1 (0.9)	4.3 (2.0)	F(1, 18)=18.53, p=.00043
Visual sharpness (fwd)	6.4 (0.7)	4.6 (1.9)	F(1, 18)=14.97, p=.00112
Fog due to environment	5.8 (0.8)	5.1 (1.7)	F(1, 19)=4.03, p=.05913
Fog due to workload	5.6 (0.9)	5.1 (1.6)	F(1, 19)=2.56, p=.12628
Field of view	6.0 (0.9)	4.6 (1.8)	F(1, 19)=14.26, p=.00128
Blind spots	5.8 (1.0)	4.9 (1.7)	F(1, 19)=5.72, p=.02726
Looking up/down	5.8 (1.0)	4.5 (1.6)	F(1, 19)=11.43, p=.00314
Looking side to side	6.1 (0.6)	4.4 (1.7)	F(1, 19)=24.37, p=.00009
Visual Acuity			
Large objects	6.4 (0.7)	5.4 (1.4)	F(1, 19)=8.37, p=.00930
Small objects	6.1 (0.7)	4.3 (1.7)	F(1, 19)=19.48, p=.00030
Low contrast objects	6.0 (0.9)	4.4 (1.3)	F(1, 19)=17.13, p=.00056
Low light	5.6 (1.3)	4.2 (1.4)	F(1, 18)=14.20, p=.00141
Target detection far (open terrain)	6.3 (0.6)	4.8 (1.6)	F(1, 19)=17.77, p=.00047
Target detection near (open terrain)	6.5 (0.6)	5.0 (1.6)	F(1, 19)=16.13, p=.00074
Target detection far (wooded terrain)	5.9 (1.1)	3.8 (1.9)	F(1, 15)=24.94, p=.00016
Target detection near (wooded terrain)	6.3 (0.9)	4.8 (1.6)	F(1, 17)=15.04, p=.00121
Target detection far (FIBUA)	6.2 (0.8)	4.3 (1.6)	F(1, 13)=18.33, p=.00089
Target detection near (FIBUA)	6.3 (0.8)	4.8 (1.7)	F(1, 17)=14.81, p=.00129
Task Performance			
Day operations	6.2 (0.5)	4.5 (1.4)	F(1, 19)=30.83, p=.00002
Obstacle traverse	6.0 (0.7)	3.9 (1.9)	F(1, 19)=21.89, p=.00016
Jungle/wooded lane	5.7 (0.9)	4.2 (1.8)	F(1, 16)=13.76, p=.00190
Vehicle course	6.2 (0.7)	4.8 (1.6)	F(1, 19)=14.66, p=.00113
Urban vehicle patrol	6.2 (0.8)	4.5 (1.5)	F(1, 19)=21.04, p=.00020
FIBUA Assault	5.9 (0.9)	4.9 (1.9)	F(1, 16)=7.16, p=.01659
Transition outside to inside (buildings)	6.3 (0.6)	5.0 (1.7)	F(1, 13)=9.16, p=.00974
Night operations	5.2 (1.7)	3.8 (1.8)	F(1, 19)=6.72, p=.01786
Overall Acceptance			
Overall visual characteristics	6.0 (0.7)	3.8 (1.5)	F(1, 19)=34.51, p=.00001
Overall task performance	5.9 (0.9)	3.9 (1.5)	F(1, 19)=38.00, p=.00001
Overall Acceptability	6.0 (0.9)	3.8 (1.5)	F(1, 19)=35.92, p=.00001

A significant effect was observed between the two ballistic visors in terms of the overall visual characteristics, task performance, and acceptability. The constant thickness ballistic visor was rated significantly more acceptable than the variable thickness ballistic visor for the majority of dimensions surveyed in the exit questionnaire. Glare and fogging issues were the only criteria not significantly differentiated between the visors. Participants strongly and consistently favoured the constant thickness ballistic visor design over the variable thickness ballistic visor. Ratings of the constant thickness ballistic visor ranged from “barely acceptable” to “reasonably acceptable” whereas the variable thickness ballistic visor was rated between “barely unacceptable” and “barely acceptable”.

Once participants completed the acceptability portion of the exit questionnaire, they were asked to rank the visors for the various visual characteristics, visual acuity, and task performance criteria. For each question participants were asked to the visor which performed best in their evaluation as one (1) and the worst as two (2). Table 9 details the ranking results of both ballistic visors.

Table 9: Exit Questionnaire Ranking Results

Mean (Standard Deviation)	Constant Thickness	Variable Thickness	Statistical Analysis (p<0.05)
Visual Characteristics			
Visual distortion	1.0 (0.1)	2.0 (0.1)	N=20 T=0.0 Z=3.82 p=0.000132
Depth perception	1.0 (0.1)	2.0 (0.1)	N=20 T=0.0 Z=3.82 p=0.000132
Nausea	1.3 (0.3)	1.8 (0.3)	N=20 T=0.0 Z=2.80 p=0.005062
Eye fatigue	1.2 (0.3)	1.8 (0.3)	N=20 T=7.5 Z=2.82 p=0.004729
Headaches	1.2 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.29 p=0.000982
Visual glare/haze	1.3 (0.4)	1.7 (0.4)	N=20 T=36.0 Z=1.91 p=0.055214
Visual sharpness (side)	1.1 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.51 p=0.000438
Visual sharpness (fwd)	1.2 (0.3)	1.9 (0.3)	N=20 T=8.5 Z=3.07 p=0.002093
Fog due to environment	1.4 (0.4)	1.6 (0.4)	N=20 T=28.0 Z= 1.22 p=0.221331
Fog due to workload	1.4 (0.4)	1.7 (0.4)	N=20 T=19.5 Z=1.52 p=0.126091
Field of view	1.2 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.29 p=0.0000982
Blind spots	1.2 (0.3)	1.8 (0.3)	N=20 T=0.00 Z=2.93 p=0.003346
Looking up/down	1.1 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.51 p=0.000438
Looking side to side	1.1 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3,51 p=0.000438
Visual Acuity			
Large objects	1.2 (0.3)	1.8 (0.3)	N=20 T=0.0 Z=3.06 p=0.002218
Small objects	1.1 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.61 p=0.000293
Low contrast objects	1.2 (0.3)	1.9 (0.3)	N=20 T=8.5 Z=3.07 p=0.002093
Low light	1.2 (0.3)	1.8 (0.3)	N=19 T=18.0 Z=2.79 p=0.005618
Target detection far (open terrain)	1.2 (0.3)	1.8 (0.3)	N=20 T=8.0 Z=2.95 p=0.003143
Target detection near (open terrain)	1.2 (0.2)	1.9 (0.2)	N=20 T=0.0 Z=3.29 p=0.000982
Target detection far (wooded terrain)	1.1 (0.2)	1.9 (0.2)	N=17 T=0.0 Z=3.40 p=0.000655
Target detection near (wooded terrain)	1.1 (0.3)	1.9 (0.3)	N=18 T=8.0 Z=2.95 p=0.003143
Target detection far (FIBUA)	1.2 (0.2)	1.8 (0.2)	N=12 T=0.00 Z=2.52 p=0.011719
Target detection near (FIBUA)	1.2 (0.2)	1.8 (0.2)	N=18 T=0.0 Z=3.05 p=0.002218
Task Performance			
Day operations	1.1 (0.3)	1.9 (0.3)	N=20 T=20.0 Z=3.01 p=0.002543
Obstacle traverse	1.2 (0.3)	1.8 (0.3)	N=20 T=8.0 Z=2.95 p=0.003143
Jungle/wooded lane	1.2 (0.3)	1.8 (0.3)	N=17 T=7.0 Z=2.69 p=0.007133
Vehicle course	1.2 (0.3)	1.8 (0.3)	N=20 T=7.0 Z=2.69 p=0.007133
Urban vehicle patrol	1.2 (0.3)	1.8 (0.3)	N=20 T=7.5 Z=2.82 p=0.004729
FIBUA Assault	1.2 (0.3)	1.8 (0.3)	N=17 T=0.0 Z=2.66 p=0.007686
Transition outside to inside (buildings)	1.3 (0.3)	1.7 (0.3)	N=15 T=0.0 Z=2.36 p=0.017961
Night operations	1.2 (0.4)	1.8 (0.4)	N=20 T=28.5 Z=2.48 p=0.013052
Overall Ranking			
Overall visual characteristics	1.1 (0.2)	1.9 (0.2)	N=20 T=10.0 Z=3.42 p=0.000625
Overall task performance	1.1 (0.2)	1.9 (0.2)	N=20 T=10.0 Z=3.42 p=0.000625
Overall ranking	1.1 (0.3)	1.9 (0.3)	N=20 T=21.0 Z=3.13 p=0.001713

A significant effect was observed between the two ballistic visors rankings in terms of overall visual characteristics, task performance, and overall ranking. Wilcoxon matched pairs analyses showed the constant thickness ballistic visor was ranked significantly better than variable thickness ballistic visor for the majority of questions. Again, glare and fogging issues were the only criteria not significantly differentiated between the visors. On the whole the participants favoured the constant thickness ballistic visor design over the variable thickness ballistic visor.

Results from the exit questionnaire, both acceptability and rankings, strongly point to the constant thickness ballistic visor as the preferred visor.

4.3 Focus Group

The exit focus group was conducted after all soldiers had completed all evaluation exercises with both ballistic visors. A summary of the soldier's comments regarding both ballistic visors during the focus group discussion is presented.

The majority of soldiers (18 of 20) reported that the variable thickness ballistic visor had some type of noticeable visual distortion whereas two soldiers indicated noticing a visual distortion with the constant thickness ballistic visor. Additionally, twelve soldiers from the variable thickness condition and two from the constant thickness condition noted that the visor required them to turn their head to focus on targets throughout the trial due to some type of visual effect caused by the ballistic visor.

The majority of soldiers (16 of 20) considered the constant thickness ballistic visor to be superior to the variable thickness ballistic visor for day tasks especially for OP/control point tasks. Additionally, fourteen soldiers considered the constant thickness ballistic visor better during the vehicle courses.

Fifteen soldiers agreed that they would select the constant thickness ballistic visor over the variable thickness ballistic visor if given the choice of one of the two ballistic visors. The remainder of the soldiers (5) stated that they did not have a preference which visor was issued.

None of the soldiers had problems with visor-helmet alignment, set-up, or falling apart during the trial. This suggests that the current visor mounting system is adequate. Several soldiers (5) commented that the current rubber stopper on the visor, designed to create air space, caused some distortion in their vision during use.

In summary, the soldiers preferred the constant thickness ballistic visor to variable thickness ballistic visor design.

5. Discussion

A battery of scientific human factors performance tests was conducted at CFB Edmonton to evaluate constant and variable thickness ballistic visors. The criteria evaluated included visual characteristic, visual acuity, task performance, and overall user acceptance. A summary of overall findings from this trial is given in Table 10, where appropriate the visor with significantly higher acceptance ratings is noted.

Table 10: Summary of Results

Task	Target Detection Performance	Task Questionnaire Acceptability Ratings	Exit Questionnaire Acceptability Ratings	Exit Questionnaire Rankings
Obstacle Course	NA	Constant thickness visor	Constant thickness visor	Constant thickness visor
Wooded Lane Course	No significant difference	Constant thickness visor	Constant thickness visor	Constant thickness visor
Vehicle Course	No significant difference	Constant thickness visor	Constant thickness visor	Constant thickness visor
Vehicle Urban Patrol Course	NA	Constant thickness visor	Constant thickness visor	Constant thickness visor
Night Patrol Course	No significant difference	No significant difference	Constant thickness visor	Constant thickness visor
FIBUA	NA	Constant thickness visor	Constant thickness visor	Constant thickness visor
Overall				
Visual Characteristics	NA	NA	Constant thickness visor	Constant thickness visor
Task Performance	NA	NA	Constant thickness visor	Constant thickness visor
Overall	NA	NA	Constant thickness visor	Constant thickness visor

Soldiers considered the constant thickness ballistic visor significantly more acceptable and ranked it better than the variable thickness ballistic visor for a variety of task and visual performance criteria. No significant differences between visors were seen in target detection performance or task questionnaire acceptability ratings for the night patrol task.

5.1 Recommendations

The results of this trial suggest that CTS should pursue the fielding of a constant thickness ballistic visor vice a variable thickness visor for integrated ocular and upper face protection.

6. References

National Institute of Justice Technology Assessment Program Riot and Face Shields. NIJ Standard-0104.02. US Dept Justice, Washington DC, 1984.

Belkin, M., Treister, G. and Dotan, S. (1984) Eye injuries and ocular protection in the Lebanon War, 1982. Isr. J Med Sci. 1984 Apr; 20(4):333-8.

Fact sheet: Ballistic Eyewear. (n.d.) Retrieved October 2, 2006, from http://www.army.forces.gc.ca/Chief_Land_Staff/Clothe_the_soldier/hab/PDF/FactSheets/BEW-fs_e.pdf

Hovis, J.K. and Chou, R (1998*) Optical Properties of Ballistic Visor. Department of National Defence.* Contract No. W7711-6-7290/01-SRV.

Lori, G., Menta, F., Matteo, L. and Giani, G.G. (2005) Optical sheet for use in manufacturing a cylindrically shaped optically correct visor and method of manufacturing said visor, U.S. Patent 6,893,126.

Tack, D.W. and Gaughan, P.M. (2000) *Evaluation of Prototype General Purpose Visor Concepts.* Humansystems Inc. contractor report performed in partial fulfillment of DCIEM Contract No. W7711-7-7429/01-SRV, December 2000.

Wong, T.Y., Seet, M.B. and Ang, C.L. (1997) *Eye injuries in twentieth century warfare: a historical perspective* .SuryOpthalmol. 1997 May-Jun; 41(6):433-5

Annex A: Task Acceptability Questionnaire

Daily Questionnaire: Visor

PERSONAL DATA Clearly print your Subject Number in the boxes provided.

NAME: ________________ **SUBJECT NUMBER:** ________________

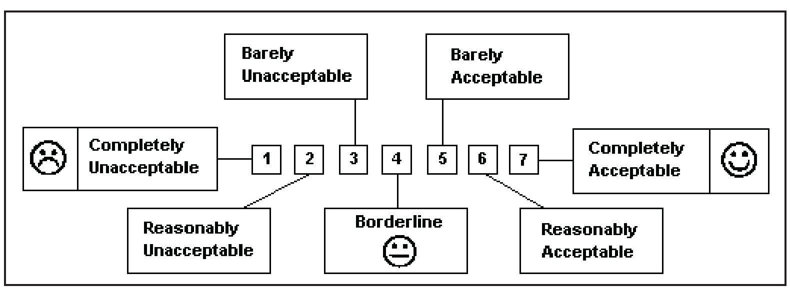
MOC: __________________ **DATE:** ____________________________

TASK: Obstacle Course ○ Jungle Lane ○ Vehicle Course ○
Urban Vehicle Patrol ○ FIBUA Assault ○ Night operations ○

Visor: Visor 1 ○ Visor 2 ○

DIRECTIONS:

After using the visor, please provide ratings of acceptance for visual characteristics, task performance and overall acceptance, using the 7-point scale below.



In addition to the space provided for comments, please use the back of the questionnaire for further elaboration and comments. If you make a mistake on the rating assessment, circle the correct answer. Check **N/A** if not appropriate

COMMENTS

Visual Characteristics	1	2	3	4	5	6	7	N/A
Visual distortion	○	○	○	○	○	○	○	○
Field of view	○	○	○	○	○	○	○	○
Depth perception	○	○	○	○	○	○	○	○
Nausea	○	○	○	○	○	○	○	○
Visual glare/haze	○	○	○	○	○	○	○	○
Visual sharpness (side)	○	○	○	○	○	○	○	○
Visual sharpness (fwd)	○	○	○	○	○	○	○	○
Fog due to environment	○	○	○	○	○	○	○	○
Fog due to workload	○	○	○	○	○	○	○	○
Eye fatigue	○	○	○	○	○	○	○	○
Headaches	○	○	○	○	○	○	○	○
Task Performance	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**N/A**
Target detection far	○	○	○	○	○	○	○	○
Target detection near	○	○	○	○	○	○	○	○
Target detection (front)	○	○	○	○	○	○	○	○
Target detection (sides)	○	○	○	○	○	○	○	○
Day tasks	○	○	○	○	○	○	○	○
Obstacle traverse	○	○	○	○	○	○	○	○
Jungle/wood lane	○	○	○	○	○	○	○	○
Vehicle course	○	○	○	○	○	○	○	○
Urban vehicle patrol	○	○	○	○	○	○	○	○
FIBUA assault	○	○	○	○	○	○	○	○
Walking	○	○	○	○	○	○	○	○
Running	○	○	○	○	○	○	○	○
Twilight tasks	○	○	○	○	○	○	○	○
Night tasks	○	○	○	○	○	○	○	○

Annex B: Exit Acceptability Questionnaire

Exit Rating Questionnaire: Visor

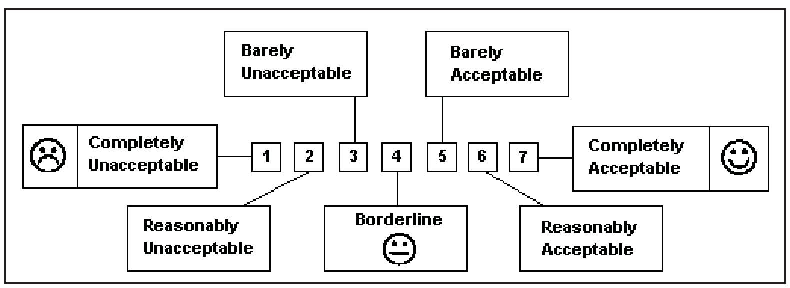
PERSONAL DATA **Clearly print your Subject Number in the boxes provided.**

NAME: ________________________ **SUBJECT NUMBER:** ________________

MOC: _________________________ **DATE:** ____________________________

DIRECTIONS FOR RATING:

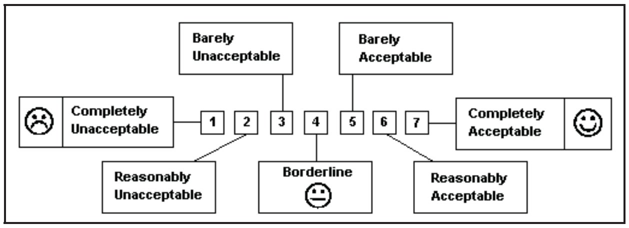
After using the visor, please provide ratings of acceptance for visual characteristics, visual acuity, task performance and overall acceptance, using the 7-point scale below.



In addition to the space provided for comments, please use the back of the questionnaire for further elaboration and comments. If you make a mistake on the rating assessment, circle the correct answer. Check N/A if not appropriate.

COMMENTS

Visual Characteristics	Visor 1							Visor 2						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Visual distortion	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Depth perception	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Nausea	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Eye fatigue	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Headaches	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Visual glare/haze	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Visual sharpness (side)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Visual sharpness (fwd)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Fog due to environment	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Fog due to workload	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Field of view	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Blind spots	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Looking up/down	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Looking side to side	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Visual Acuity	1	2	3	4	5	6	7	1	2	3	4	5	6	7
Large objects	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Small objects	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Low contrast objects	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Low light	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection far (open terrain)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection near (open terrain)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection far (wooded terrain)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection near (wooded terrain)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection far (MOUT)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Target detection near (MOUT)	○	○	○	○	○	○	○	○	○	○	○	○	○	○



Task Performance	**Visor 1**							**Visor 2**						
	1	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Day operations	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Obstacle traverse	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Jungle/wooded lane	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Vehicle course	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Urban vehicle patrol	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Advance to contact	○	○	○	○	○	○	○	○	○	○	○	○	○	○
FIBUA Assault	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Transition outside to inside (buildings)	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Night operations	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Overall Acceptance	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Overall visual characteristics	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Overall task performance	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Overall Acceptability	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Annex C: Exit Ranking Questionnaire

Exit Ranking Questionnaire: Visor

Personal Data **Clearly print your Subject Number in the boxes provided.**

NAME: ________________________ **SUBJECT NUMBER:** ______________

MOC: _________________________ **DATE:** _________________________

DIRECTIONS FOR RANKING:

After using both visors, please rank the visors in order of merit for each criterion, using the following for ranking system.

> Score the visor which performed best in your evaluation as one (1) and the worst as two (2) for each.

In addition to the space provided for comments, please use the back of the questionnaire for further elaboration and comments. If you make a mistake on the ranking assessment, circle the correct answer. N/A if not appropriate.

COMMENTS

Please rank the both visors in order of merit for the criteria below. Score the visor which performed best in your evaluation as one (1) and the worst as two (2).		
	Visor 1	**Visor 2**
Visual Characteristics		
Visual distortion		
Depth perception		
Nausea		
Eye fatigue		
Headaches		
Visual glare/haze		
Visual sharpness (side)		
Visual sharpness (fwd)		
Fog due to environment		
Fog due to workload		
Field of view		
Blind spots		
Looking up/down		
Looking side to side		
Visual Acuity		
Large objects		
Small objects		
Low Contrast objects		
Low light		
Target detection far (open terrain)		
Target detection near (open terrain)		
Target detection far (wooded terrain)		
Target detection near (wooded terrain)		
Target detection far (MOUT)		
Target detection near (MOUT)		

Please rank the both visors in order of merit for the criteria below. Score the visor which performed best in your evaluation as one (1) and the worst as two (2).		
	Visor 1	**Visor 2**
Task Performance		
Day operations		
Obstacle traverse		
Jungle/wooded lane		
Vehicle course		
Urban vehicle patrol		
Advance to contact		
FIBUA Assault		
Transition outside to inside (buildings)		
Night operations		

Overall Acceptance		
Overall visual characteristics		
Overall task performance		
Overall Acceptability		

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Human Factors Evaluation of two Optically Different Ballistic Visors (U)

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Harry A. Angel; Paul G. Santos Vilhena ; Andrew Morton

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(U) A four−day field trial was undertaken at CFB Edmonton over the period of June 12 to 16 2006 to evaluate the difference between constant and variable thickness ballistic visors. Twenty infantry soldiers, regular (n=5) and reserve (n=15) force, of various Canadian units were required to undertake a battery of human factors tests while wearing two different visor conditions in a fully balanced repeated measures design. The trial was split into three phases: the clinical testing, trial overview, and scale explanation; dynamic activities; and focus group. Evaluation exercises included an obstacle course, wooded lane course, vehicle course, urban vehicle patrol course, night patrol course, and FIBUA assault. The participants rated visual characteristics, visual acuity, and task acceptability of the visors for each evaluation exercise. Data collection included target detection performance measures, acceptability ratings, preference rankings, and focus group. Overall, a constant thickness ballistic visor was preferred by participants to a variable thickness ballistic visor for the majority of the human factors criteria. Objective target detection performance data showed no differences between the visors. Clothe the Soldier (CTS) Project is recommended to proceed with the requirement for a constant thickness ballistic visor for the integrated ocular and upper face protection.

(U) Un essai sur le terrain de quatre jours a été effectué à la BFC Edmonton du 12 au 16 juin 2006 afin d’établir la différence entre les visières balistiques d’épaisseur constante et les visières balistiques d’épaisseur variable. On avait besoin de vingt fantassins, soit cinq de la Force régulière et 15 de la Réserve, appartenant à diverses unités canadiennes qui devaient entreprendre une batterie d’essais usuels selon une formule parfaitement équilibrée de mesures répétées en portant deux genres de visières. L’essai était divisé en trois phases : l’essai clinique, l’aperçu de l’essai et l’explication de l’échelle; les activités dynamiques; le groupe de discussion. Les exercices d’évaluation comprenaient un parcours du combattant, un parcours en sentier boisé, un parcours en véhicule, un parcours de patrouille urbaine motorisée, un parcours de patrouille de nuit et le combat dans les zones bâties. Les participants ont coté, dans chaque exercice d’évaluation, les caractéristiques visuelles, l’acuité visuelle et l’acceptabilité des visières aux fins d’exécution des tâches. La collecte des données comprenait les mesures du rendement au niveau de la détection des cibles, les cotations de l’acceptabilité, le classement des préférences et le groupe de discussion. Dans l’ensemble, les participants ont préféré la visière balistique d’épaisseur constante à la visière balistique d’épaisseur variable concernant la majorité des critères. Les données objectives relatives au rendement au niveau de la détection des cibles ne montraient aucune différence entre les visières. On recommande, dans le cadre du projet Habillez le soldat, de continuer à demander une visière balistique d’épaisseur constante en vue d’assurer la protection intégrée des yeux et de la partie supérieure du visage.

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(U) Clothe the Soldier; CTS; Ballistic Visor; Human Factors; Vision Protection

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